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A CRITICAL EVALUATION ON POZZOLONIC PROPERTIES OF SELECTED MATERIALS AND THEIR REPLACEMENT IN CEMENT

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ABSTRACT

Increase in population in the country is demanding more and more infrastructure projects and housing which intern is demanding more and more cement manufacturing. This is resulting in releasing of huge amount of CO2 into the atmosphere which is causing environmental problems. There is a need to look for alternative materials which lessen emanation of green house gasses. As a piece of this various alternative materials to cement have been explored by various researchers. In the present study it is focused on basalt, fly ash, metakaolin, tank sediments, sludge of vitrified ceramic tile plant, clayey soil and clay deposits. Published articles related to the pozzolonic materials are collected and complied.

Most relevant papers are sorted out and studied in depth to understand the problems, methodology, results obtained and conclusions drawn. Metakaolin was tried by several researchers and it is found to be promising At Present metakaolin available in the market is costly and this cost factor is one of the constraint in utilization, hence we need to explore alternative low cost materials that can be used in the place of existing metakaolin after treatment.

Key words: Fly Ash, Metakaolin, Basalt, Alternative Materials, Clay

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1. INTRODUCTION

The most common binding materials that are used as concrete constituents in addition to Ordinary Portland cement are fly fiery debris (ash), ground granulated impact heater slag and metakaolin. The above mentioned materials are available abundant in nature and they have many technical benefits. The main ingredient of concrete is cement which results about nearly 7% of global warming and carbon dioxide emission into the atmosphere. The partial replacements of these materials such as metakaolin, basalt, fly ash, tank sediments and sludge of vitrified ceramic tiles reduces the problems such as carbon dioxide emissions and reduce heat of hydration from the Ordinary Portland cement.

Fly ash is a byproduct from coal based thermal power plants in our country. It has been generally considered a waste material in the past and disposal of this particular material has posed numerous ecological and environmental problems

In the present scenario fly ash is considered as the resource material rather than a waste material in civil engineering as well as in material science. In developing countries like India power generation is most important requirement for economic and social development. During 1947, the installed capacity was 1,361 MW, which has increased to 1, 87, 732 MW on 31 March, 2012. Out of it, 1, 10, 232 MW is thermal (Coal/Lignite) based and is responsible to co-generate nearly 200 million tons of fly ash per year. In 12th Five Year Plan, the Planning Commission has set up target to enhance power capacity by 89,000MW, out of which 53,400 MW will come from Coal/Lignite based thermal power plants. By the end of 12th Plan (2017), the fly ash generation is expected to reach 300 million tons per year and likely to continue to grow with same pace at least for next two to three decades. As there is a huge availability of fly ash in our country this can be converted as a useful material in several civil engineering applications.

China clay resources in the country as per united nations framework classifications (UNFC) system as on 1.4.2010 have been placed at 2,705.21 million tones. The reserves constitute only about 7% of the resources at 177.16 million tones. Out of the total reserves, 70% (about 124 million tones) reserves are under proved category whereas 30% (about 53 million tones) reserves fall under probable category. The resources are spread over in a number of states of which Kerala holds about 25%, followed by West Bengal and Rajasthan (16% each) and Odisha and Karnataka (10% each). Out of total resources, about 22% or 608 million tones fall under ceramic/pottery grade, 4% are classified under chemical, paper filler and cement grades and about 73% or 1,980 million tones resources fall under mixed grade, others, unclassified & not-known categories.

Gujarat was the leading producing state of kaolin accounting for 54% of the total production in 2012-13 followed by Kerala (24%), Rajasthan (16%), West Bengal (3%) and Jharkhand (2%). The remaining 1% was shared by Andhra Pradesh, Karnataka and Madhya Pradesh.

In Western and Central India, basalt is exposed mainly in the states of Maharashtra, Madhya Pradesh, Karnataka, Gujarat, and Andhra Pradesh and also has its nominal presence in southern parts of Uttar Pradesh and eastern parts of Rajasthan. These kind of rocks are mostly available in Kovvuru region in Andhra Pradesh. These rocks are used to make in to fibers having a density of 2.64 g/cc which is extensively used in concrete for filling the voids present in the concrete which ultimately provides the good compressive strength for the respective mix design. Because of the abandoned availability of these materials in Indian they are considered in the present comparative study of pozzolonic properties.

1.1. Basalt

It is volcanic rock which is shaped because of cooling and recrystalization of magma. Basalt is generally dark to dark in shading, yet quickly climates to chestnut or rust-red because of oxidation of its mafic (iron-rich) minerals into rust. Albeit generally described as "dim", basaltic rocks show an extensive variety of shading because of local geochemical forms.

1.1.1. Properties of Basalt

Basalt is a molten rock with under 20% quartz and under 10% feldspathoid by volume, and where no less than 65% of the feldspar is as plagioclase .Basalt highlights a polished network scattered with minerals. It has great pozzolanic property and gives higher qualities when blended with cement and is most generally utilized as a part of development exercises.

1.1.2. Basalt Fibre in Concrete

Majorly cleaved Basalt Fiber is as a rule widely utilized as a part of the development business in light of the fact that these strands are more grounded than steel and 89% lighter.

1.2. FLY ASH

The utilization of Fly Ash in development is an answer for natural corruption being created by concrete industry. The idea all that much fits into the time of reasonable advancement. Fly fiery debris is one of the deposits made amid the ignition of coal in coal-terminated force plants. Fine particles ascend with fuel gasses and are gathered with channel sacks or electrostatic precipitators Fly fiery debris is a waste by-item material that must be discarded or recycled.131 million tons of fly powder are delivered yearly by 460 coal-let go force plants in the U.S. alone.

1.2.1. Properties of Fly Ash

Fly fiery remains is a by-result of blazing pummeled coal in an electrical delivering station. Specifically, it is the unburned development that is diverted from the blazing zone in the evaporator by the pipe gasses and after that gathered by either mechanical or electrostatic separators The heavier unburned material drops to the base of the heater and is termed base slag. The execution of fly slag in cement is unequivocally affected by its physical, mineralogical and compound properties. The mineralogical and concoction synthesis are needy to a vast degree on the organization of the coal and since an extensive variety of household and imported coals (anthracite, bituminous, sub-bituminous and lignite) are blazed in distinctive creating stations in North America, the properties of the fly fiery debris can be altogether different in the middle of sources and gathering routines. The smoldering conditions inside of a force plant can likewise influence the properties of the fly fiery remains. It is of 2 sorts class C and mud F. Class F fly cinder is accessible in the biggest amounts. It is for the most part low in lime ordinarily under 20% and contains a more noteworthy mix of silica, alumina and iron. Class C fly cinder regularly groups lime content from 15% to 30%. Raised CaO may give novel self solidifying attributes

1.2.2. Fly Ash in Concrete

Roman structures including the water channels and the Pantheon in Rome utilized volcanic slag which have fundamentally the same properties to fly fiery remains .Use of fly powder as a pozzolanic fixing was perceived as ahead of schedule as 1914 however first huge investigation of its utilization in Portland cement was in 1937.30% of fly cinder in the U.S. is reused into making concrete.

1.3. METAKAOLIN

Metakaolin is another era of supplementary tying material. Utilization of metakaolin in bond based frameworks gives specialized and in addition natural advantages. It is exceptional in that it is not the by result of a modern procedure nor it is totally natural. It is gotten from a normally happening mineral and it is produced uniquely to cement applications. It is for the most part delivered by warm process that is calcinations of kaolin dirt with an unequivocal range. Calcinations of earth mineral (kaolin) at reasonably high temperature (650-800oC) separates the precious stone structure creating a move stage (silica and shapeless alumina in responsive structure) of high surface territory .Optimum blazing temperature will rely on upon the base mineral.

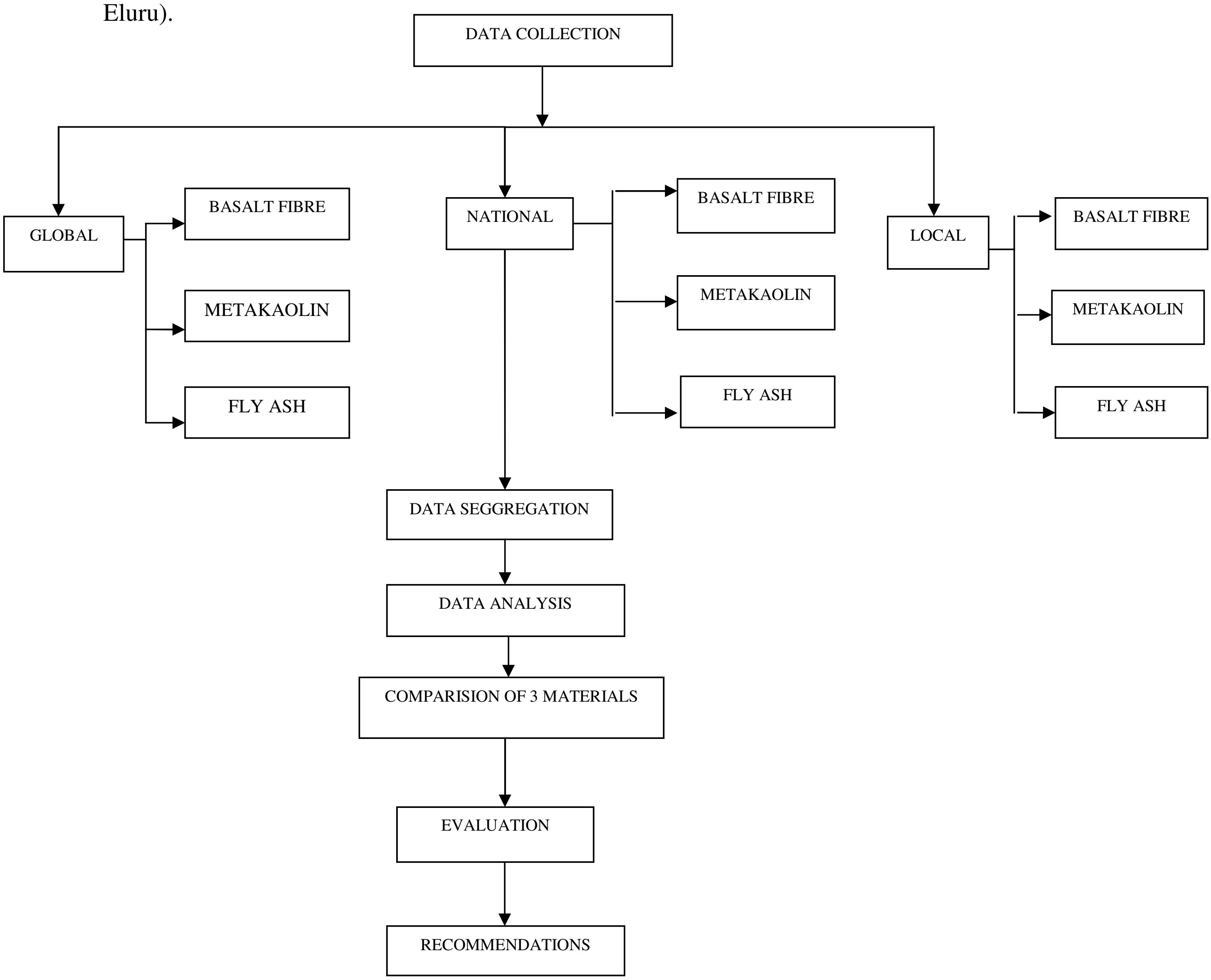
1.3.1. Metakaolin in Concrete

Very responsive pozzolan with high particular surface Replacement level will rely on upon the way of the constituents and the response time Enhances a few mechanical (early-age compressive quality, flexural quality) and solidness properties (substance assault, ASR development, sulfate resistance, F/T cycles) of cement

2. OBJECTIVES: Comparison and evaluation of pozzolonic properties of Basalt fiber, Metakaolin and Fly ash.

3. METHODOLOGY

Selection of the interested topic. Collection of published papers relevant to the topic. Reading, Understanding and extracting the information. Compiling the results obtained from literature review. Preparation of model paper.The information regarding the availability of materials was gathered. The availability of basalt in this region is near Kovvuru and the availability of clay is Dwaraka Thirumala (near Eluru).



(a) Flow chart of methodology

4. RESULT

4.1. Basalt

“Basalt as pozzolona and filler in opc” In this paper basalt is used as replacement in cement as 5%,10%,15%,20% by total weight. They concluded as 20% is optimum percentage to attain maximum strength. **(H. El-Didamony 2015)**

“Strength of concrete containing basalt fibre”. Basalt fibre is replaced 0.5%, 1%,2% by total weight. In this paper they concluded that strength will increase till 1% and after that it decreases rapidly. (**Parvez Imraan Ansari 2015**)

“Stren gth Aspects of Basalt Fiber Reinforced Concrete”. Basalt fibre is replaced with 0.24 %, 0.5 % & 1% by total weight. 1% gives the maximum strength. **(Fathima Irine I .A 2014**)

4.2. Flyash

“Fly ash concrete: a technical analysis for compressive strength”. flyash is used as replacement as 5-25%. The optimum percentage is 10-20% provides higher strength. **(Dr S L Pati1 2012)**

“Experimental investigations on partial replacement of cement with fly ash in design mix concrete”. Fly ash is replaced 10 – 40% by total weight and 10 % replacement will give the maximum strength. **(Jayeshkumar Pitroda 2012)**

“Effect of class f flyash as partial replacement with cement and fine aggregate in mortar”. Fly ash is used as 10%, 20% , 25% &30%. by weight. 10 % replacement will give the maximum strength. **(C freeda 2010)**

“Effect of fly ash on properties on concrete”. In this work the percentage of concrete used was 10%,20% and 30% by total weight and found that 10% - 20% gives the maximum strength after 30 days. **(P. R. Wankhede 2014)**

“High volume fly ash concrete: a green concrete”. In this particular work fly ash was used from 25% to 60% by total weight and the optimum percentage was found to be 15%- 20%.**(Vanita Aggarwal 2012)**

4.3. Metakaolin

“Strength properties of metakaolin admix concrete”. Metakaolin 5%, 10%15% & 20 % by weight is replaced. Results indicated that 15% will gives the maximum strength. **(Nova John 2013)**

“Investigation on behavior of high performance reinforced concrete columns with metakaolin and fly ash as admixture”. Metakaolin : 5%,7.5% 10%.and fly ash : 10% constant is used as replacement. 7.5 % is the optimum percentage where maximum strength is achieved. **(P.Muthupriya 2011)**

“Effect of partial replacement of cement by meta kaolin in sifcon”. Steel fibres : 5% and Metakaolin : 10% results indicate that these percentages provide optimum strength**. (Niveditha.A 2014)**

“The effect of metakaolin on concrete properties”. Metakaolin is used as replacement 10% , 20% by weight. optimum percentage is 10% where maximum strength is achieved. **(E. Badogiannis 2002)**

“The effect of iran’s metakaolin in enhancing the concrete compressive strength”. Metakaolin is replaced 5%,10%, 15% & 20 % by its weight. optimum percentage is 10% - 20 %. (**A. Sadr Momtazi)**

5. CONCLUSION

We observe that the strength aspects of concrete are more or less equal in all the three types of materials when they are partially replaced in the cement.

The ductility property of concrete is increased when the cement is replaced with basalt fiber due to the physical structure of basalt fiber.

The properties such as permeability and resistance to sulphur attack is also increased to certain limit while replacing with metakaolin as well as fly ash.

When the strength aspects are considered, fly ash is the best material which can be replaced in cement for better results and it is economical.

As per the environmental perspective, basalt fiber is the best pozzolonic material for partial replacement in cement.

Table 1 Relative comparison of pozzolonic materials

BASALT FIBRE	METAKAOLIN	FLY ASH
Range :0.5% -2%	Range : 5%- 20%	Range : 5% - 40%
Optimum content : 1%	Optimum content : 10%	Optimum content : 15%
Cost (per kg): very high	Cost (per kg): high	Cost (per kg) : economical
Environmental perspectives: maximum reduction in emission of carbon di oxide	Environmental aspects: moderate reduction is emission of carbon di oxide is observed when this material is used as partial replacement in ordinary Portland cement.	Environmental aspects: maximum reduction in emission of carbon di oxide is observed when this material is used as partial replacement in ordinary Portland cement.
Performance	**Performance**	**Performance**
Ductility : yes	Ductility :no	Ductility : no
Strength : yes	Strength : yes (early strength)	Strength : yes
Permeability : no	Permeability : yes	Permeability : yes
Sulphur attack : no	Sulphur attack : yes	Sulphur attack : yes

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